Bird Study (2009) **56,** 264–267

SHORT REPORT

Male nest-building activity influences clutch mass in Pied Flycatchers *Ficedula hypoleuca*

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Capsule Some males brought building materials to nests and females who were paired with such males laid heavier clutches.

NEST BUILDING IN PIED FLYCATCHERS *FICEDULA HYPOLEUCA* HAS BEEN REPORTED TO BE DONE EXCLUSIVELY BY FEMALES AFTER PAIR-FORMATION AND NEST BUILDING TAKES BETWEEN 4–11 DAYS (CURIO 1959, LUNDBERG & ALATALO 1992, DEL HOYO *ET AL.* 2006). FEMALES COLLECT NEST MATERIAL TENS OR EVEN HUNDREDS OF METRES FROM THE NESTS (HAARTMAN 1956) DURING BOUTS OF ACTIVITY WITH PAUSES OF ABOUT 10 MIN-UTES (CURIO 1959).

TO INDUCE FEMALE NEST-BUILDING ACTIVITY PIED FLYCATCHER MALES DISPLAY DIFFERENT POSTURES ACCOMPANIED BY SOUND UTTERANCES (CURIO 1959) AND, SOMETIMES, MALES ACCOMPANY FEMALES DURING THE COLLECTION OF NESTING MATERIAL (CREUTZ 1955). WHILE NEST BUILDING IS CONSIDERED TO BE DONE EXCLUSIVELY BY FEMALES THERE ARE A FEW REPORTS OF UNUSED NESTS APPARENTLY BUILT BY UNPAIRED MALES, AND RUDIMENTARY NESTS BUILT BY MALES (SEE REFERENCES IN CRAMP 1993). IN ADDITION, WE HAVE OCCASIONALLY OBSERVED MALE PIED FLYCATCHERS CARRYING MATERIAL FOR NEST BUILDING TO THEIR NESTBOXES. IN THIS STUDY OUR AIM WAS TO DESCRIBE AND QUANTIFY, TO OUR KNOWLEDGE FOR THE FIRST TIME, THE OCCURRENCE OF MALES ENGAGING IN NEST-BUILDING ACTIVITIES. IN ADDITION, WE HAVE TESTED FOR THE POSSIBLE ROLE OF MALE NEST-BUILDING BEHAVIOUR AS AN EXTERNAL POST-MATING SEX-UAL SIGNAL AFFECTING FEMALE INVESTMENT IN REPRODUCTION, AS HAS BEEN REPORTED PREVIOUSLY IN OTHER AVIAN SPECIES (PALOMINO *ET AL.* 1998, SOLER *ET AL.* 1998, 2001).

THIS STUDY WAS CONDUCTED IN SPRING OF 2004 ON A POPULATION OF PIED FLYCATCHERS BREEDING IN NESTBOXES IN VALSAÍN, CENTRAL SPAIN (40° 53' N, 4° 01' W). BOXES WERE INSPECTED DAILY TO DETECT INITIATION OF NEST CONSTRUCTION. DURING THE NEST-BUILDING PERIOD WE FILMED 19 NESTBOXES FOR 3 HOURS EACH WITH VIDEO CAMERAS PLACED IN FRONT OF THE BOX ENTRANCE AT AN APPROXIMATE DISTANCE OF 10 M. IN AN ADDITIONAL NEST, VIDEO FILMING LASTED 90 MINUTES. FILMING TOOK PLACE BETWEEN 10:30 AND 16:30 (LOCAL TIME). MALE AND FEMALE VISITS WITH AND WITHOUT NEST MATERIAL TO THEIR NEST WERE ANALYZED FROM THE FILMS. BIRD SEX WAS IDENTIFIED BY PLUMAGE. THE NUMBER OF NEST VISITS WAS EXPRESSED AS AN HOURLY RATE. WE HAVE ASSUMED THAT PIED FLYCATCHERS BRINGING NEST MATERIAL TO A NESTBOX WERE THOSE THAT LATER BRED IN THAT BOX. SUBSEQUENT DAILY INSPECTIONS OF THE NESTBOXES ALLOWED US TO DETERMINE LAYING DATE AND CLUTCH SIZE. IN ADDITION, EACH EGG WAS WEIGHED WITH A PORTABLE ELECTRONIC BALANCE TO THE NEAREST 0.1 G AND LAYING DATE AND TOTAL CLUTCH MASS DETERMINED. WITH THE EXCEPTION OF TWO FEMALES, WE TRAPPED FEMALE PIED FLYCATCHERS IN NESTBOXES WHILE THEY WERE FEEDING THEIR NESTLINGS ONE DAY AFTER HATCHING. AT THAT CAPTURE EACH FEMALE WAS WEIGHED TO PROVIDE AN APPROXIMATION TO FEMALE MASS AT LAYING, A POTENTIAL VARIABLE AFFECTING EGG MASS. WE ASSUMED THAT FEMALE MASS AT HATCHING WAS POSITIVELY ASSOCIATED WITH HER MASS AT LAYING. THE WHOLE OPERATION TOOK LESS THAN 5 MINUTES, AND NO FEMALE ABANDONED THE NEST BECAUSE OF CAPTURE. MANY

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females continued inside their nestbox after being placed back on the nest. Twelve days after hatching males were trapped and their age and body condition calculated (mass divided by tarsus·length).

Statistica version 6.0 was used for statistical analyses. We employed simple correlations to analyze the association between male and female visits carrying/not carrying nest material. ANCOVA analyses were used to investigate the association between laying date, clutch size (dependent variables) and male building activity (factor; see results), and female visits carrying nest·building material (covariable). In addition, an ANOVA analysis was used to study the potential associa· tion between male building activity (as a factor; see results) and total clutch mass. This relationship was also confirmed by an ANCOVA analysis including the total clutch mass as dependent variable, male building activity as a factor, female visits carrying nest material, female mass, and laying date as covariables. Mann- Whitney *U*·tests were used to investigate the relation· ship between male age and condition with male visits carrying nest material.

Nests filmed in this study were used by females to lay their clutches. Among the total number of nests filmed, 16 males and 16 females were observed visiting nest· boxes and, among them, 5 males (25% of the total num· ber of males) and 11 females (55% of the total number of females) were observed carrying some kind of nest· building material such as leaves, straw, a piece of wood or bark of *Cistus* sp. We did not observe clear differences in the size or type of materials carried by males and females, but potential differences were not quantified. The number of male visits without material per hour to the nest was highly positively correlated with the num· ber of female visits without material (Spearman's rank correlation: r_s = 0.72, N = 20, P < 0.001). In the case of birds carrying nest material, we observed 0.67 ± 0.24 male visits carrying nest material per hour and 1.88 ± 2.33 female visits with nest material per hour. Male and female visits carrying nest material were not significantly associated (Spearman's rank correlation: r_s = 0.37, N = 20, P = 0.10). Due to the fact that only five males were observed carrying nest material and that the number of their visits was much lower than those by females, we transformed male visits to a categorical variable (nests where males were filmed carrying nest material *versus* nests where males were not filmed carrying nest·material) for the following analyses.

We did not find associations between laying date or clutch size, and male or female visits carrying nest· building material (ANCOVA: all Ps > 0.40). However, those females paired with males who were filmed car· rying nest material to their nests laid heavier clutches (Fig. 1, $F_{1,18}$ = 16.77, P < 0.001). This association was also significant after controlling for the effect of different variables that could potentially influence this association (ANCOVA: male visits carrying nest material: $F_{1,13}$ = 5.87, P = 0.03; female visits carrying nest·building material: $F_{1,13}$ = 0.67, P = 0.43; female mass: $F_{1,13}$ = 0.88, P = 0.36; laying date: $F_{1,13}$ = 0.048, P = 0.83). Male age and condition were not signifi· cantly associated with male visits with nest material (all Ps > 0.30).

In our study population we recorded that a relatively high proportion of paired males carried nest material to the nestbox. We suggest that those males we observed carrying nest material contributed to nest building and may have done so at a higher rate than we actually observed. The fact that not all females were observed carrying nesting material, although they were building the nest, may support this possibility. Male contribu· tion to nest building is, however, low compared with female investment. It is possible that males bringing material to a nest is an inductive behaviour to increase female nest·building activity. However, we could not investigate this possibility due to the absence of a sig· nificant association between male and female visits carrying nesting material. In this context, it is possible that other male behaviours, such as pouncing and nest· showing displays, may be more frequently used than carrying nesting material to induce an increase in female building activity (Curio 1959).

Our results suggest that male activity carrying nest material could act as a signal of male quality that induces females to increase their reproductive effort (Soler *et al.* 1998). Alternatively, males carrying mate· rial to nests may signal to females their predisposition to invest in current reproduction. If male nest·building activity represents a sexual display, an increase in female parental investment could be associated with an increase in nest size and also nest·building activity by males (Palomino *et al.* 1998, Soler *et al.* 1998, 2001). For example, in barn swallows *Hirundo rustica*, larger clutches were laid by females from nests built by pairs carrying more material (Soler *et al.* 1998). However, we did not find any significant association between nest· building behaviour and clutch size in the present study, in agreement with reports from other avian species where nest size was not related to clutch size (Herranz *et al.* 2004, Suárez *et al.* 2005, Tomás *et al.* 2006). Also, the positive association between male nest·building activity and clutch mass could be interpreted as male

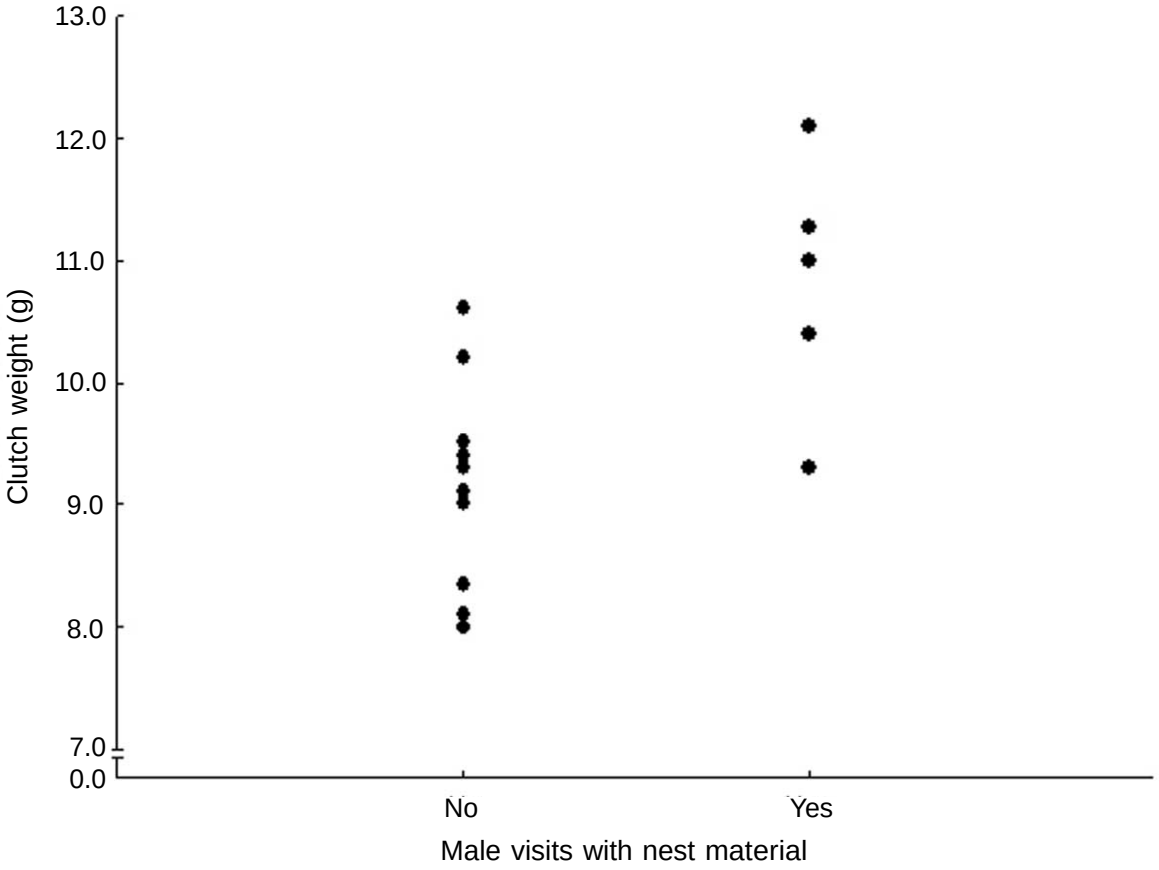

Figure 1. Relationship between clutch mass and presence/absence of male visits carrying nest material ($F_{1,18}$ = 16.77; P < 0.001).

INDUCTION TO INCREASE REPRODUCTIVE INVESTMENT BY FEMALES. IT IS KNOWN THAT FEMALES CAN ADJUST THEIR REPRODUCTIVE INVESTMENT ACCORDING TO THE DEGREE OF ATTRACTIVENESS OF THEIR MATES (BURLEY 1986, DE LOPE & MØLLER 1993, SHELDON 2000), WHICH COULD RESULT IN AN INCREASE IN THE SIZE AND QUALITY OF THEIR EGGS WHEN PAIRED WITH PREFERRED MATES (GIL *ET AL.* 1999; CUNNINGHAM AND RUSSELL 2000). THEREFORE, IF A MALE BRINGING MATERIAL TO A NEST IS A SIGNAL OF MALE QUALITY OR FUTURE INVESTMENT, THE INCREASE IN CLUTCH MASS WOULD BE ADVANTAGEOUS FOR FEMALES IN ORDER TO INCREASE THEIR OWN REPRODUCTIVE SUCCESS.

IN A PREVIOUS STUDY IN THE SAME POPULATION OF PIED FLYCATCHERS, OSORNO *ET AL.* (2006) FOUND THAT AN EXPERIMENTAL INCREASE IN A SECONDARY SEXUAL TRAIT, THE SIZE OF THE MALE FOREHEAD PATCH, INDUCED FEMALES TO LAY SIGNIFICANTLY LARGER EGGS THAN THOSE PAIRED WITH MALES WITH REDUCED FOREHEAD PATCH SIZE. THIS EARLIER STUDY TOGETHER WITH OUR PRESENT RESULTS SUGGEST THAT FEMALE PIED FLYCATCHERS IN OUR POPULATION COULD ADJUST THEIR MATERNAL INVESTMENT IN THEIR EGGS IN RELATION TO SECONDARY SEXUAL TRAITS OR BEHAVIOUR OF THEIR MATES. ALTERNATIVELY, IF MALES OF BETTER QUALITY ARE THOSE WHO CONTRIBUTE TO NEST BUILDING, THEY MAY ALSO BE THE ONES PAIRED TO THE FEMALES OF BETTER QUALITY LAYING HEAVIER EGGS. IT COULD ALSO BE POSSIBLE THAT FEMALES OF BETTER QUALITY INDUCE MALES TO CONTRIBUTE TO NEST-BUILDING ACTIVITY. NEST BUILDING IS PHYSIOLOGICALLY EXPENSIVE (HANSELL 2000) AND FEMALE PIED FLYCATCHERS SHOWING HIGHER RATES OF NEST CONSTRUCTION EXHIBIT AN INCREASE IN THEIR LEVEL OF STRESS RESPONSE PROTEINS (MORENO *ET AL.* 2008). THEREFORE, MALE CONTRIBUTION TO NEST BUILDING COULD REDUCE THE COSTS DERIVED FROM THAT ACTIVITY FOR FEMALES, ALLOWING THEM TO INVEST MORE RESOURCES IN CLUTCH MASS.

ACKNOWLEDGEMENTS

THIS STUDY WAS SUPPORTED BY PROJECTS CGL2006-14129-C02-01 TO S. MERINO AND CGL2007-61251 TO J. MORENO (DGI – MINISTERIO DE EDUCACIÓN Y CIENCIA). J. MARTÍNEZ-DE LA PUENTE IS SUPPORTED BY EL VENTORRILLO GRANT FROM CSIC, E. LOBATO WAS SUPPORTED BY A FPU GRANT AND J. MORALES AND G. TOMÁS BY

POSTDOCTORAL GRANTS FROM MEC. WE WERE AUTHORIZED BY J. DONÉS, DIRECTOR OF CENTRO MONTES DE VALSAÍN (MINISTERIO DE MEDIO AMBIENTE) TO WORK IN THE STUDY AREA. DIRECCIÓN GEN- ERAL DEL MEDIO NATURAL (JUNTA DE CASTILLA Y LEÓN) AUTHORIZED THE CAPTURE, RINGING AND SAMPLING OF BIRDS. WE THANK T. CALVO FOR HER INVALUABLE HELP IN THE FIELD. THIS PAPER IS A CONTRIBU- TION FROM THE FIELD STATION 'EL VENTORRILLO'. THIS STUDY COMPLIES WITH THE CURRENT SPANISH LAWS. TWO ANONYMOUS REFEREES CON- SIDERABLY IMPROVED A PREVIOUS VERSION OF THE MANUSCRIPT.

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(MS received 24 April 2008; revised MS accepted 1 September 2008)